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# An investigation of coastal climate change risk assessment practice in Australia

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ABSTRACT

Local government organisations in coastal Australia have historically commissioned studies aimed at understanding risks in their locality to future sea level rise as a starting point for developing adaptation strategies to climate change. Therefore, the success of the overall adaptation activities of local government are strongly influenced by the way those initial risk studies are scoped and conducted, and how the outputs of those studies underpin subsequent adaptation planning activities within the organization. Mainstreaming of adaptation planning activities within local government is critical in terms of getting stakeholder support and required resources for its implementation. This paper analyses a sample of these coastal risk assessment studies across seven states and territories in Australia, with an aim to critically investigate the current state of practice among coastal local governments. First, we develop a typology of studies that have been undertaken by or for practitioners to understand coastal climate change risks, and discuss the applicability of the studies within the policy-making context of local government. Second, we identify a set of sample studies from the 'grey literature' through a systematic process and investigate to what extent they adhere to best practice risk management guidelines and principles, such as ISO31000. Third, we interview stakeholders from top performing studies to identify how/if the risk studies helped their organization in progressing their adaptation planning. We find that there is a significant inconsistency among terminologies in the coastal climate change risk assessment unpublished literature as studies use "risk", vulnerability" and "hazard" concepts interchangeably despite their separate objectives and aims. Most studies perform poorly in evaluating risk against broader organizational criteria. Subsequently, it is difficult to integrate the findings of such studies into a broader organizational risk register, limiting opportunities for identified coastal climate change risks to be integrated into councils' long-term strategic decision making. Conversely, the follow up interviews of studies that performed well in scoping and consultation in our assessment demonstrate that these aspects were beneficial to stakeholders in terms of informing adaptation planning. Importantly, the findings presented in this paper confirm the need for a consistent risk assessment approach for local councils in the coastal zone to underpin successful adaptation planning. This is a critical issue, not only for Australia, but for local government organisations globally given that sea level rise is a projected threat for all populated coastal regions worldwide.

## 1. Introduction

Sea level rise as a result of anthropogenic climate change poses significant risks to settlements and infrastructure in the coastal zone around the world. Of the 63 most populated cities of the world (with 5 million or more inhabitants in 2011), 72 per cent are located on or near the coast (United Nations, 2012). The coastal population (within 100 km of the shoreline and up to 100 m above sea level) is estimated at 1.2 billion people, with a significant amount of infrastructure and built environment supporting this population. The economic implications of

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sea level rise are major, with global annual investment and maintenance costs of protecting the coast estimated to be US$ 12–71 billion in 2100 (Hinkel et al., 2014). Australia, with approximately 85% of the population living within 50 km of the coast and 710,000 addresses below 6 m elevation, relies heavily on the coastal zone for livelihood (Watson 2011). The most recent Intergovernmental Panel on Climate Change (IPCC) report, AR5, outlines sea level rise scenarios ranging from a 0.55 m to 1.25 m increase by 2100 (IPCC, 2014). In addition, an increase in the frequency and intensity of coastal storms is projected (Allen et al., 2014), with the potential for tropical cyclones to affect regions of the Australian coast further south than at present (Walsh and Katzfey, 2000). Coastal settlements are likely to be impacted by this rise in sea level and its associated processes such as permanent submergence, an increase in periodic flooding of low lying areas, increased flooding during extreme events (e.g. tropical/extratropical cyclones, storm surges), erosion and changes to estuaries and wetlands (Lin et al., 2014; Walsh et al., 2004; Mcinnes et al., 2016; Ayyub and Kearney, 2012).

Coastal local governments in Australia will face immense challenges to safeguard their communities, and the infrastructure systems that serve them. Increasing efforts are being made by different tiers of Government in understanding and managing these risks and planning for adaptation (Heazle et al., 2013; Measham et al., 2011; Preston and Kay, 2010; Kiem et al., 2014). Although local government is largely guided by state level planning policies and guidelines in Australia (Gurran et al., 2013), it remains the implementing agency for managing Australian coastlines. Therefore, it is the responsibility of coastal local governments to plan for managing coastal hazards and their associated risks to public and private assets. In order to assist local governments to understand these coastal risks and plan for adaptation, a range of guidelines are provided by state governments in Australia, with those guidelines sometimes supported by funding resources (Preston and Kay, 2010). As a result, a significant amount of 'grey literature' or unpublished reports have been generated by this sector, focusing on understanding location specific coastal risks relating to sea level rise. However, the effectiveness of these guidelines and the resulting studies, in terms of developing and implementing sea level rise adaptation plans, has yet to be explored.

A necessary component of climate change adaptation research is the development of robust and consistent methodologies for understanding and managing climate change risks (e.g. Jones, 2001; Bass et al., 1997; Tonmoy and El-Zein, 2013, 2018; Heazle et al., 2013; Hammill and Tanner, 2011; Linkov et al., 2006; El-Zein and Tonmoy, 2015; Tonmoy et al., 2014). Conceptual framing of climate change risks has emanated from a range of disciplines such as a) natural hazard (e.g. Romieu et al., 2010; Smith, 2013; Bründl et al., 2009), b) vulnerability (e.g. Adger et al., 2004; Eakin and Luers, 2006; Turner et al., 2003; O'brien et al., 2004), and c) resilience (e.g. Folke, 2006; Turner, 2010). These different approaches result in varying terminologies and abstract concepts, such as hazard, risk, vulnerability, and resilience, being applied in research and, subsequently, to guide policy development and influence climate change risk management and adaptation practice (Fünfgeld and Mcevoy, 2011). While each of these concepts have their own objectives and usefulness in climate change adaptation, their inconsistent use in policy development and practical application can add another layer of uncertainty to the already vexing issue of adaptation decision making.

ISO 31000 (2009) "*Risk management principles and guidelines*" provides guidance on how to scope, conduct, communicate and use risk assessment studies within a broader risk management framework. Although these guidelines are not specifically for climate change risks, they have been used or adopted by different agencies (e.g. federal, state and territory governments etc.) for providing guidance to local governments about understanding and managing climate change risks. Additionally, in order to assist practitioners to manage climate change risks, a number of risk based adaptation frameworks have been proposed with an aim to standardise terminologies and processes (e.g. Willows et al., 2003; Ago, 2006; AS5334, 2013; NCCARF, 2017). These frameworks are based on standard risk management principles similar to ISO31000 (2009), and are tailored to the needs of different sectors or users to support them to manage their organizational and business risks. This general familiarity of risk management frameworks among the public and private sectors has contributed to climate adaptation increasingly framed in the context of risk (Preston and Kay, 2010). Other research such as Jones and Preston (2011) argues that there are certain limitations to the way risk based approaches have been applied in practice, notably when they a) do not recognise socioeconomic elements of vulnerability and adaptation, b) dislocate adaptation to climate change from other changes in associated human-environmental systems or c) are unable to capture 'deep uncertainty' associated with future socioeconomic states and evolution of other complex systems contributing to climate change. Nevertheless, risk based approaches have been dominantly used in developing adaptation policy guidelines.

Research has shown that adhering to the risk management principles and guidelines at a high level is a significant factor leading to the achievement of project goals and in managing risks (Olechowski et al., 2016). While this hasn't been specifically tested in relation to climate change risks, it could be assumed that coastal risk assessment studies which adhere more closely to the ISO 31000 standard are less likely to become redundant over time and more likely to remain consistent with assessments from different sectors that make up the overall decision making environment for government in Australia. However, even if a coastal risk assessment adheres closely to standard risk management principles, this does not necessarily ensure the uptake of the generated information by council decision makers (Measham et al., 2011). There are certain barriers that often impede adaptation planning. These include uncertainty in the degree of expected future changes, lack of leadership and community support for adaptation, and lack of resources for investigation or implementation of adaptation actions, (Measham et al., 2011; Preston et al., 2011a; Storbjörk, 2007). For example, while investigating observed adaptation in the United Kingdom, Tompkins et al. (2010) identified that, among other factors, engagement with stakeholders by local government can play a big part in progressing climate change risk management activities.

To the best of our knowledge, no study has investigated the adherence of unpublished 'grey literature' of coastal climate change risk studies to standard risk management principles and the resulting effectiveness of those studies within the broader coastal climate change risk management environment. Nor has any study considered the efficacy of risk assessment and its dependence on understanding broader issues relating to framing or understanding of the problem (otherwise known as "Establishing the Context") and the communication of that context and the risk assessment with stakeholders and the local community.

In this paper our objective is three-fold. First, we develop an evaluation framework using standard risk management principles, similar to ISO31000 (2009) to analyse "grey literature" (i.e. studies that do not appear as peer reviewed academic literature) of coastal sea level rise related risk studies in Australia. Second, we use that framework to examine a sample of sea level rise risk assessment studies, conducted across different states in Australia, to investigate to what extent these studies adhere to these principles. Third, we selected top performers from our assessment and interviewed the stakeholders involved in the study from the relevant council (or group of councils) to understand the utility of those studies for the progression of meaningful adaptation actions.

## 2. Typology of studies conducted by coastal councils to understand sea level rise risks

In order to investigate the state of practice of the coastal climate change studies in Australia, we first identify typologies of studies conducted by coastal councils to understand sea level rise risks. Three types

**Table 1**
Example of study typologies generally found in the grey literature that are used by local government authorities in Australia to inform their coastal adaptation planning (not an exhaustive list).

| Type of study | Description | Key characteristics and relevance in adaptation planning | Example |
|---|---|---|---|
| Impact assessment | These studies analyse the impact of climate change on natural, social and economic systems. Generally broad in scope. | Often conducted by regional local government bodies at the preliminary stage of the adaptation planning | Marden Jacob Associates (2010) |
| Coastal Vulnerability assessment | These studies consider the characteristics of a given system and investigate potential impact of climate change and sea level rise on the system. It is implemented in many different ways using different definitions of vulnerability; therefore comparability of results of these studies across scale is limited. | • Provides insights in understanding underlying causes of climate change and sea level rise risks at a particular location.<br>• Limited usefulness in preparing coastal zone management plan.<br>• Can be used by council's internal prioritization of adaptation resources | Balston et al. (2011), Resilient South (2014) |
| Coastal Risk assessment | These studies provide a way of dealing with inherent uncertainties of climate change impacts. Facilitates the identification of climate change risks using the same procedure that is used by the councils to identify other organizational risks, therefore relatively easier to incorporate within existing organizational procedures. | • This can be used at multiple stages of adaptation planning based on the objective. A high-level risk screening can be done at the scoping stage where as a detailed risk assessment can be done at the later stages of adaptation planning where identification of risk thresholds and prioritization is essential.<br>• Can play a crucial role in mainstream climate risks within the council. | Bayside City Council (2012) |
| Coastal Hazard assessment | These studies develop models to identify biophysical hazards in detail and propose elements to monitor in future. Provides detailed information on coastal processes (erosion, inundation) | • Typically expensive and therefore useful if they are carried out following a relatively inexpensive scoping study.<br>• Plays a crucial role in developing coastal zone management plan. | WRL (2013), Water Technology (2014) |
| Adaptation option study | Investigates different adaptation option in terms of a range of relevant criteria such as technical feasibility, coast and benefit, effectiveness in solving the problem, impact on environment and communities etc. | Relevant at the implementation stage of the adaptation planning | ACIL Tasman (2012) |

of climate change assessments have been often found at the local scale; climate hazard assessments, climate risk assessments and vulnerability assessments (Fünfgeld and Mcevoy, 2011). The choice of assessment should be based on the risk management context. However, "hazard", "vulnerability", or "resilience" studies, in isolation, only provide partial understanding of the risks of climate change and further studies are required by the organization to complete this understanding and plan for effective risk management. Among these, hazard studies are often commissioned by coastal councils to develop a detailed understanding of location specific coastal hazards, including climate change and sea level rise. Hazard studies are essential for coastal councils regardless of climate change issues as they assist in the preparation of local coastal zone management plans. Table 1 present a non-exhaustive list of study typologies, including their key characteristics and relevance in adaptation planning.

Among these multiple types of studies, in this paper we mainly focus on climate change risk assessment. This is mainly because in recent years risk management based approaches (which include risk assessments) have been advocated by different scholars as well as IPCC in their 5th Assessment report as risk based approaches allow better dealing with uncertainties and focus on solutions (i.e. managing the risks) rather the problem only (Willows et al., 2003; Bründl et al., 2009; Heazle et al., 2013; Jones and Preston, 2011; Preston et al., 2011b; Jones, 2001; Jones et al., 2014).

## 3. Development of the evaluation framework to assess unpublished risk studies associated with coastal climate change

### 3.1. Risk management principles and their relevance to sea level rise risks

We use ISO31000 (2009) as the starting point for the development of the systematic evaluation framework. The standard evolved over time, developed through a consensus driven process over four years involving input of hundreds of risk management professionals and has been broadly accepted and adopted by a range of disciplines globally (Purdy, 2010). Box 1 shows 11 risk management principles which are the core of the risk management process (to be discussed next section).

ISO31000 (2009) defines risk as the "*effect of uncertainty on objectives*". This definition has reference to two key terms, "*uncertainty*" and "*objectives*" which are crucial in terms of managing coastal climate change risks from a local government perspective. The following contribute to "*uncertainty*" from a coastal local council perspective.

- The uncertain amount of sea level rise that will occur over different time frames, and its interaction with ongoing climatic variability.
- Future changes to storm behaviour and subsequent storm surge characteristics are uncertain.
- The uncertain geomorphological response of the coastline with rising sea levels and changes to storms, given differences in sedimentary properties and behaviour (Thom et al. in prep).
- The uncertain extent, nature, resilience and value of assets that may be threatened by sea level rise, noting that asset values are likely to be a combination of environmental, social or economic; tangible or intangible.

Understanding the effects of these uncertainties on the organizational "*objectives*" of local councils is challenging. Here "*objectives*" refers to a broad set of responsibilities and organizational aims required by communities and by state and federal governments (e.g. formulation of planning policy, assessment of development proposals, providing infrastructure services to its communities). Sea level rise has the potential to influence how councils can continue to fulfil these objectives in future and coastal studies aim to support councils in this regard.

### 3.2. Risk management process

Risk management is an iterative process which predominantly involves six interrelated tasks a) establishing the context, b) risk identification, c) risk analysis and d) risk evaluation e) risk treatment and f) communication and consultation management (Fig. 1). The risk assessment process (strictly speaking, tasks a, b, c, d and f) is a subset of the risk management process, which is itself a continuous process involving ongoing review, communication and feedbacks. Risk treatment (point f) involves identification and evaluation of options which, in the

**Box 1**
Risk management principles of ISO31000 (2009).

1. Creates and protects value
2. Be an integral part of organizational processes
3. Be part of decision making
4. Explicitly address uncertainty
5. Be systematic, structured and timely
6. Based on the best available information
7. Be tailored
8. Take into account human and cultural factors
9. Be transparent and inclusive
10. Be dynamic, iterative and responsive to change
11. Facilitate the continual improvement of organisations

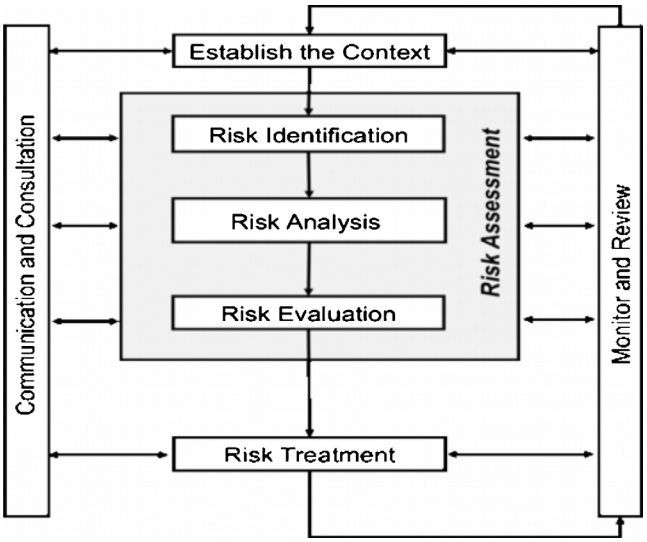


**Fig. 1.** Risk management process from ISO 31000 (2009).

context of adaptation to sea level rise, is complicated by the fact that it needs a long-term perspective, investment which may conflict with other, seemingly more immediate priorities, and needs a significant amount of consultation and engagement. Often, evaluation of risk treatment options is conducted as a separate study to risk assessment by the coastal councils in Australia and in this paper we aimed to scrutinize studies that are primarily focused on the risk assessment process.

### 3.3. Evaluation criteria

We have used ISO risk management standard as the fundamental starting point for developing a framework of investigation. The principles of that standard have been shown to be important factors in the achievement of risk management project goals (Olechowski et al., 2016). We developed a set of 23 criteria in the form of questions (Table 2). The questions were developed during a review of ISO31000 and covered each of the five relevant tasks of a risk assessment process (point a, b, c, d and f as outlined in Section 3.2). Each of these questions also relates to the underlying risk management principles from ISO31000. The 23 criteria (Table 2) were then used to evaluate the coastal studies. Note that "establishing the context" section has the most number of questions which reflects the importance of understanding the decision making context of coastal adaptation (Webb et al., 2018). Also note that, Principle 5 which highlights the importance of the studies to be systematically designed (Box 1) appears the most frequently and Principle 10 does not appear once as this mainly relates to risk treatment which is not a concern for our analysis.

## 4. Selection of risk assessment studies

### 4.1. Methodology

Our aim was to analyse studies conducted by local coastal councils in Australia. As such these are likely to comprise 'grey' literature (as opposed to peer reviewed academic literature). However, in addition to seeking these reports from organizational websites, we also conducted a search through Web of Science to identify the academic literature relating to adaptation and coastal management in Australia using the following search terms:

- "coast* AND climate change adaptation AND Australia"
- "coast* AND sea level rise AND adaptation AND Australia".

The list of search results was limited to those addressing the risk management stages relevant to the present study. All abstracts were reviewed and those of limited expected use to the present study were not considered further. Generally, the peer reviewed literature did not include sufficiently detailed case study information required for us to undertake our assessment. Therefore, an additional search of unpublished literature was conducted using multiple sources to identify relevant application studies. Further, Preston and Kay (2010) identified a list of studies conducted in Australia under different funding schemes. However not all of these were coastal and only the coastal studies were included in our study sample. The following criteria were then applied to this list of studies in order to identify the ones that matched the objective of this research.

a) Study was conducted in last 10 years, ensuring that studies were likely be more likely to be following best practice and the most recent literature.
b) Study was conducted to inform coastal climate change risks of coastal councils, ensuring that studies were relevant to our research objectives
c) Have a manageable size of samples, ensuring that the individual sampled studies were evaluated in appropriate detail.

This resulted in shortlisting of 31 studies for our analysis. Preliminary consideration showed that there was a mix of study types in our sample reflecting the typologies outlined earlier in this paper (Table 1). 17 of these studies matched with our definition of "risk assessment", 2 with "vulnerability assessment" and 3 studies used both risk and vulnerability concepts. Table 3 shows the full distribution of the initial sample. We carried forward the 17 risk assessment studies (given that risk assessment is our primary objective). Further investigation revealed that 3 of these studies were conducted either at a national scale or did not directly informing coastal councils and therefore discarded from the sample. Ultimately 14 coastal risk

**Table 2**
Evaluation criteria used for each stage of risk assessment and their relevance with risk management principles (see Box 1 to find the description of respective risk management principles).

| Risk Assessment Stage | Evaluation Criteria | Relevant risk management principles |
|---|---|---|
| Establishing the context | 1. Has the scope of the risk assessment been adequately defined, including the time frame and geographic extent? | 5 |
| | 2. Have stakeholders been identified? | 9 |
| | 3. Have the relevant legal requirements, standards and policies been identified? | 7 |
| | 4. Have relevant risk criteria been established at the outset of the study, including establishment of the way in which risks will be evaluated, including consideration of whether quantitative or qualitative measures might be applied? | 1 |
| | 5. Were stakeholders appropriately involved in the determination of risk criteria as part of context setting exercises? | 3, 9 |
| | 6. Prior to Risk Assessment being undertaken, were suitable efforts made to understand the external context and environment for the risk assessment? | 8 |
| | 7. Prior to Risk Assessment being undertaken, were suitable efforts made to define the internal context and environment for the risk assessment? | 2 |
| | 8. Does the method incorporate an up-front focus on the objectives of local government and have those objectives been well defined? | 5 |
| Risk identification | 9. Was a systematic method used to identify the risks? | 5 |
| | 10. Have the views of stakeholders been appropriately incorporated into the risk identification process? | 3 |
| | 11. Are risk descriptions presented, including consequences, their impact on objectives, the risk sources and how they arise from the environment, along with the central event itself? | 5, 8 |
| Risk analysis: likelihoods | 12. Has the best available information been used to assess likelihoods and is use of the data justified? | 6 |
| | 13. Have suitably robust methods been used to assess the likelihood, given the available data and study constraints, and has use of those methods been justified? Is uncertainty explicitly addressed? | 4 |
| | 14. Has the scale of likelihoods been determined sufficiently in a way that is consistent with well defined “risk criteria”? | 5 |
| Risk analysis: consequences | 15. Has the best available information been used to assess consequences and is use of the data justified? | 6 |
| | 16. Have suitably robust methods been used to assess the consequences, given the available data and study constraints, and has use of those methods been justified? | 5 |
| | 17. Has the scale of consequences been determined sufficiently in a way that is consistent with well defined “risk criteria”? | 5 |
| Risk evaluation | 18. Has risk evaluation been undertaken? | 5 |
| | 19. Is the method of risk evaluation consistent with the established risk criteria and the likelihood and consequences assessments? | 5 |
| | 20. Has the risk evaluation clearly indicated those risks that need further consideration? | 11 |
| Communication and consultation | 21. Have stakeholders been informed of the methods used in risk analysis and are they aware of the justification for use of those methods? | 7, 9 |
| | 22. Was the knowledge of stakeholders leveraged to obtain information on the likelihood and consequences of risks? | 2, 3 |
| | 23. Have the outcomes of the risk assessment been adequately communicated (i.e. quality of reporting). | 9 |

assessment studies were taken forward for evaluation of their adherence to risk management principles.

### 4.2. Inductive evaluation of sample studies

We undertook an inductive process in which each of the studies in our final sample was reviewed independently by the four co-authors of this paper focussing on the summaries, conclusions and sections that dealt specifically with aspects of risk assessment. The criteria shown in Table 2 were then used and individual study is ‘marked’ against each criterion using an assessment scale (Table 4) that was developed to ensure consistency and common understanding of terminologies among evaluators. (e.g. see Preston et al., 2011a) for discussion of a similar

**Table 4**
Description of scale used for scoring.

| Conditions | Score |
|---|---|
| No evidence of consideration for a particular criterion was apparent within the report which suggest this particular aspect of the risk assessment was neglected | 0 |
| Evidence exists of consideration of a particular criterion. This suggests the concept or process in question was recognised or acknowledged as being of some importance but remained underdeveloped. | 1 |
| Evidence exists of consideration of a particular criterion in the study and significant effort was invested for fulfilment of the criteria | 2 |

**Table 3**
Distribution of types of studies in our initial sample.

| Type of study | Reason for categorization | **Count** |
|---|---|---|
| Risk assessment | Uses standard risk terminologies of ISO31000 consistently with a clear link of the study output with broader risk management and adaptation strategy | 17 |
| Vulnerability assessment | Uses IPCC 2007 conceptualization of vulnerability (exposure, sensitivity and adaptive capacity) and develops vulnerability ratings. It do not use likelihood and consequences in the estimation | 2 |
| Hazard assessment | Develop models to identify biophysical hazards and propose elements to monitor in future. Provides detail information on coastal processes (erosion, inundation) but no clear connection on how this information will be used to evaluate risks to develop a risk management strategy (when to intervene or how to prioritise investment etc.). | 5 |
| Impact assessment | Aims to understand impacts of climate change on a particular system. It often uses exposure and sensitivity dimension of IPCC framework | 2 |
| Adaptation option assessment | Covers part of risk management framework (i.e. investigate option) | 2 |
| VA and RA mix | Uses both concept in an inconsistent way | 3 |

scale. The 'averaged' scores for each individual criterion were adopted as a final performance indicator for that study against that particular criterion. The criterion scores were summed for each study to give a score for overall performance. For this analysis, each criterion was weighted evenly. For ease of presentation and discussion, final performance scores were then normalized to 100, meaning that full marks would have resulted in a score of 100%.

### 4.3. Limitation of this methodology

A number of limitations apply to the evaluation framework and the sample selection.

First, establishing the context of the risk assessment has more criteria compared to other steps, which could provide studies with better scoping an advantage in their evaluation. This conscious choice was made by the study team as we wanted to investigate to what extent studies provide contextual information and draw the necessary boundaries for the risk environment. This is crucial as, without proper scoping and description of how coastal climate change risk assessment fits within the broader risk management environment of the council, a study which is otherwise technically very sound, could ultimately be of limited practical use. However, there is a possibility that some studies do not include all background work in their report, even though sound scoping of the work happened prior to it and reporting of that was not a requirement from the council. This would disadvantage such a study in our ranking. On the other hand, our main objective of this evaluation was to develop a broader understanding of risk assessment practice within coastal councils, rather than to rigorously rank different studies and define the "best" one among our sample. The main reason for a relative ranking was to identify a short list of representative organisations for follow up interviews to assess whether adherence to best practice risk management principles had resulted in clear and positive adaptation outcomes.

Second, we did not aim to capture all possible coastal climate risk studies from the grey literature. Instead, we used a systematic approach to identify a group of studies based on our predefined criteria. Therefore, it is likely that some relevant studies have not been included in our sample. However, a manageable sample size was necessary to scrutinize studies in further detail and to develop a broader understanding of coastal climate change risk management practice in Australia. Nevertheless, the sample is representative enough for the purpose of this study.

Third, the sample studies were evaluated using an inductive process which brings certain subjectivity in the scoring process. However, to minimize this limitation, scoring was completed individually by all four authors of this study and an average of the scoring was used for further analysis of results.

### 4.4. Follow up interviews of stakeholders from top performing studies

In order to investigate to what extent the better performing studies actually helped the host organization in progressing their adaptation journey, we selected the top six performing studies and conducted interviews with persons from the host organisations who were involved in that particular study and in a position to shed some light on utility of that study for the host organization's perspectives. Roles of these stakeholders ranged from project coordinators, coastal engineers to strategic planners within each organization.

Interview questions were designed with an aim to engage with stakeholder of the host organization and centered on the following themes, although broader issues arose and were discussed:

1. Overall, how well did the climate change risk assessment meet the needs of the Council?
2. What were the key components that made the project a success/what were the key components that were missing that could have improved the study?
3. What was the level of engagement between the team that carried out the study and the stakeholders (including Council) during project initiation and throughout? How was communication of the project results addressed and what was the success/failure in this regard?
4. Were the results of the study transferred into action plans that were compatible with current Council risk management strategies/approaches?
5. Where attempts were made to transfer results and recommendations into action, (i) how readily were the action plans implemented and (ii) how successful were the action plans?

Interviews were conducted on one-on-one basis with proper ethics approval in place. Information were noted and compiled together and finally analysed to draw insights.

## 5. Results

### 5.1. Vulnerability assessment vs risk assessment: lack of consistency among terminologies

Our sample selection process identified significant inconsistencies in the terminologies used in climate change risk assessments and climate change vulnerability assessments. As an example, even after searching web sources with terms specifically for climate change risk assessments, there are studies in our initial sample that included "vulnerability" in their title (i.e. climate change risk and vulnerability assessments) and further investigation in those studies revealed that either those studies conducted a risk assessment but used the word 'vulnerability' interchangeably with 'risk' or the studies made a fusion of both risk and vulnerability concepts and often in an inconsistent way. Fünfgeld and Mcevoy (2011) argued that the overlapping of different disciplines in climate change domain brought about different perspectives which lead to inconsistent use of terminologies such as risk, vulnerability, resilience and hazard among researchers which ultimately end up in policy documents which can then cause confusion among practitioners. This inconsistency was clearly evident in our sample. Often, coastal practitioners are guided by a set of guidance documents that are available to them from an overarching authority (e.g. state government, federal government etc.). Table 5 shows a range of state level guidance documents available to practitioners in Australia and how they dealt with risk and vulnerability terminologies and a lack of consistency is also evident in some of these guidelines. The South Australian guideline clearly uses a vulnerability assessment approach which translated into the studies conducted by South Australian coastal councils and, as we only selected risk assessments, there was no study from South Australia in our final sample.

It should be noted that both risk and vulnerability assessments are important tools for coastal councils and have their own purpose and objectives. Vulnerability assessments aim to measure the susceptibility of council to harm by identifying most vulnerable systems (i.e. infrastructure, sector, assets) and not necessarily measure the impact of the vulnerable systems on the corporate objectives of the council (e.g. maintain the desired level of service of public infrastructure). On the other hand, risk assessments identifies specific risks of each system of the council to climate change harms and investigate the likelihood and consequences of these risks to evaluate its impacts on council's overarching objective. Both of these two types of studies can be complementary to each other as it may be possible that a coastal council can apply vulnerability as an additional layer or filter on top of the results of their risk assessment in order to further prioritise their response. However, inconsistent use of these two concepts can diminish the usefulness of the outputs of the conducted studies.

**Table 5**
Guidelines available to local governments for managing coastal risks and how risk and vulnerability assessments have been used in them.

| State | Guidelines for local governments in managing coastal risks | Predominant approach in the document | How vulnerability assessment is used in the guidelines |
|---|---|---|---|
| Queensland | 1. Developing a Coastal Hazard Adaptation Strategy: Minimum Standards and Guideline for Queensland Local Governments (LGAQ, 2016)<br>2. Guideline for preparing a coastal hazard adaptation strategy (Queensland Government, 2013) | 1. Risk based approach with reference to vulnerability assessment<br>2. Risk based approach | 1. Vulnerability assessment is conducted first then followed by a risk assessment<br>2. No reference to vulnerability assessment |
| New South Wales | 1. Draft NSW coastal management manual (OEH, 2015)<br>2. Guide to Climate Change Risk Assessment for NSW Local Government (OEH, 2011) | 1. Risk based approach with reference to vulnerability assessment<br>2. Risk based approach with reference to vulnerability assessment | 1. The word vulnerability is used but a vulnerability assessment per se is not required<br>2. Vulnerability assessment is clearly distinguished from the risk assessment and suggested as a separate policy prioritization exercise |
| Western Australia | Coastal Hazard Risk Management and Adaptation Planning Guidelines, (Western Australia Planning Commission, 2014) | Risk based approach with reference to vulnerability assessment | Vulnerability assessment is conducted first then followed by a risk assessment |
| South Australia | South Australian guidelines for developing a climate change adaptation plan and undertaking an integrated climate change vulnerability assessment (LGASA, 2014)) | Risk based approach with heavily grounded in vulnerability terminologies | Vulnerability assessment is conducted instead of risk assessment using likelihood and consequences. As a result no reference to evaluation of risk with organizational criteria |
| Victoria | Victorian Coastal Hazard Guide (Victorian Government, 2012) | Risk based approach | No mixture of risk and vulnerability based approaches |
| Tasmania | Mitigating Natural Hazards through Land Use Planning and Building Control Coastal Hazards Technical Report (Tasmanian Goverment, 2013) | Risk based approach | No mixture of risk and vulnerability based approaches |

### 5.2. Ranking of coastal climate risk studies

Scores and rankings of our study samples are analysed further. Table 6 shows the total score of each of the 17 studies normalized to a scale of 100 for ease of discussion and presentation. Only one study scored more than 80, with 7 studies (50% of the sample) scoring in the 61–80 range (Fig. 2). The two lowest performing studies scored below 40.

In order to gain more insight, we focused our analysis on the individual criteria scores, which showed that average scores of the criteria varied between minimum of 0.6 and a maximum of 1.8 (out of 2) (Table 7). The poorest performing criteria were criteria 5 and 19 (average score of 0.6 out of 2). These two criteria related to aspects of risk evaluation: determining evaluation criteria through proper stakeholder engagement (criterion 5) and evaluating identified risks against

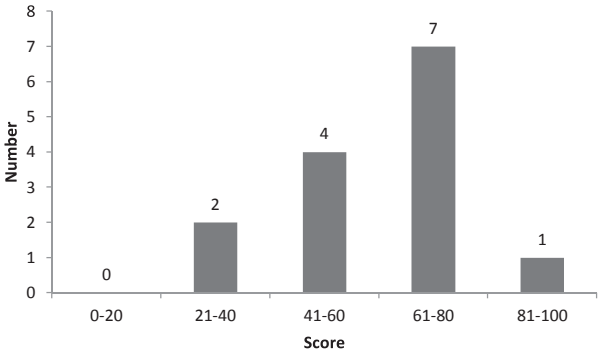


**Fig. 2.** Frequency distribution of the scores of individual risk assessment study. For easier representation, scores are normalized to 100.

**Table 6**
Average score of evaluation questions for each sample study (average of four evaluators).

| | Evaluation question number and the step of the ISO31000 framework that they belong | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Establishing the context | | | | | | | | Risk identification | | | Risk Analysis: Likelihoods | | | Risk Analysis: Consequences | | | Risk Evaluation | | | Communication and Consultation | | | |
| Study identifier | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | Normalized score [a] (out of 100) |
| | Average score for each criteria (average of 4 observations) | | | | | | | | | | | | | | | | | | | | | | | |
| **4** | 2.0 | 1.3 | 2.0 | 1.6 | 0.0 | 1.3 | 1.3 | 0.5 | 2.0 | 0.5 | 1.3 | 1.8 | 1.3 | 2.0 | 1.5 | 1.5 | 2.0 | 2.0 | 2.0 | 2.0 | 1.5 | 1.4 | 2.0 | **76.0** |
| **6** | 1.6 | 0.7 | 2.0 | 1.2 | 0.5 | 0.7 | 0.7 | 0.0 | 0.7 | 0.5 | 0.0 | 1.5 | 1.0 | 1.6 | 1.0 | 1.3 | 1.6 | 1.6 | 0.0 | 1.5 | 0.5 | 2.0 | 1.0 | **50.2** |
| **8** | 2.0 | 0.7 | 2.0 | 2.0 | 0.5 | 0.7 | 1.3 | 1.5 | 0.3 | 0.3 | 2.0 | 1.0 | 0.3 | 2.0 | 0.8 | 1.0 | 2.0 | 2.0 | 0.0 | 2.0 | 1.0 | 1.7 | 0.5 | **59.9** |
| **9** | 2.0 | 1.3 | 0.7 | 2.0 | 1.5 | 1.3 | 0.7 | 1.5 | 0.3 | 0.8 | 0.7 | 2.0 | 1.5 | 1.6 | 1.5 | 1.3 | 2.0 | 1.2 | 1.0 | 2.0 | 1.5 | 1.4 | 1.0 | **67.0** |
| **10** | 2.0 | 1.3 | 0.0 | 2.0 | 2.0 | 0.7 | 0.7 | 2.0 | 1.0 | 1.3 | 0.0 | 1.0 | 0.5 | 0.0 | 1.8 | 1.3 | 1.0 | 1.2 | 1.3 | 2.0 | 0.5 | 1.1 | 1.5 | **56.9** |
| **14** | 1.2 | 0.7 | 2.0 | 0.4 | 0.0 | 1.3 | 0.0 | 1.0 | 0.0 | 1.3 | 0.0 | 0.8 | 1.3 | 0.4 | 1.0 | 0.3 | 0.0 | 0.4 | 0.0 | 1.0 | 0.5 | 1.4 | 2.0 | **36.9** |
| **18** | 0.4 | 0.7 | 0.7 | 2.0 | 0.5 | 0.7 | 0.7 | 0.5 | 0.3 | 0.5 | 1.0 | 0.5 | 0.3 | 0.0 | 2.0 | 1.3 | 1.6 | 2.0 | 0.7 | 2.0 | 0.0 | 1.7 | 1.3 | **46.3** |
| **22** | 0.4 | 0.7 | 0.7 | 1.6 | 0.0 | 0.7 | 0.0 | 0.0 | 0.0 | 0.3 | 0.7 | 2.0 | 1.2 | 2.0 | 2.0 | 1.3 | 2.0 | 2.0 | 0.0 | 2.0 | 0.8 | 0.0 | 1.5 | **47.1** |
| **23** | 2.0 | 2.0 | 1.3 | 2.0 | 0.0 | 2.0 | 0.7 | 1.5 | 1.7 | 1.5 | 1.7 | 0.3 | 1.7 | 2.0 | 0.5 | 1.3 | 2.0 | 2.0 | 0.0 | 2.0 | 2.0 | 2.0 | 2.0 | **74.1** |
| **26** | 2.0 | 1.3 | 1.3 | 0.0 | 1.0 | 2.0 | 0.7 | 0.0 | 0.3 | 0.3 | 1.3 | 1.5 | 1.0 | 1.6 | 1.8 | 1.3 | 2.0 | 1.2 | 0.0 | 2.0 | 1.5 | 2.0 | 1.5 | **60.1** |
| **29** | 1.6 | 0.7 | 0.7 | 2.0 | 0.5 | 1.3 | 1.3 | 2.0 | 2.0 | 0.5 | 1.0 | 0.3 | 1.7 | 2.0 | 0.3 | 1.3 | 2.0 | 2.0 | 0.7 | 2.0 | 0.5 | 1.1 | 2.0 | **63.9** |
| **30** | 0.0 | 1.3 | 0.0 | 0.0 | 0.0 | 2.0 | 0.0 | 0.5 | 0.0 | 0.0 | 0.3 | 0.8 | 0.8 | 1.6 | 1.3 | 1.7 | 2.0 | 2.0 | 0.0 | 0.0 | 1.5 | 0.9 | 0.0 | **36.1** |
| **31** | 2.0 | 2.0 | 0.8 | 2.0 | 2.0 | 0.8 | 0.0 | 1.5 | 2.0 | 2.0 | 2.0 | 0.3 | 1.0 | 2.0 | 1.3 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 1.5 | 2.0 | 2.0 | **80.7** |
| **32** | 2.0 | 0.7 | 1.3 | 0.0 | 0.5 | 1.3 | 1.3 | 0.5 | 1.7 | 0.3 | 1.0 | 1.5 | 1.7 | 1.6 | 2.0 | 1.0 | 1.2 | 2.0 | 0.7 | 2.0 | 0.0 | 2.0 | 2.0 | **61.3** |

[a] Sum of all questions were normalized and converted to scores out of 100 using simple arithmetic.

**Table 7**
Average scores for each stages and individual criterion for the whole sample (column 2 and 4 respectively). Column two shows average score for a particular stage. Column five to eight shows number of studies in different ranges of scores.

| Stages of risk assessment | Average score of the stage | Criteria | Average score of the criteria | Number of study that scored 0 | Number of study that scored > 0 | Number of study that scored between 1 and 2 | Number of study that scored 2 |
|---|---|---|---|---|---|---|---|
| Establishing the context | 1.1 | 1 | 1.5 | 1 | 13 | 3 | 8 |
| | | 2 | 1.1 | 0 | 14 | 5 | 2 |
| | | 3 | 1.1 | 2 | 12 | 3 | 4 |
| | | 4 | 1.3 | 3 | 11 | 3 | 7 |
| | | 5 | 0.6 | 5 | 9 | 1 | 2 |
| | | 6 | 1.2 | 0 | 14 | 5 | 3 |
| | | 7 | 0.7 | 4 | 10 | 4 | 0 |
| | | 8 | 0.9 | 3 | 11 | 4 | 2 |
| Risk identification | 0.8 | 9 | 0.9 | 3 | 11 | 2 | 3 |
| | | 10 | 0.7 | 1 | 13 | 3 | 1 |
| | | 11 | 0.9 | 3 | 11 | 3 | 2 |
| Risk Analysis: Likelihoods | 1.2 | 12 | 1.1 | 0 | 14 | 4 | 2 |
| | | 13 | 1.1 | 0 | 14 | 7 | 0 |
| | | 14 | 1.5 | 2 | 12 | 5 | 6 |
| Risk Analysis: Consequences | 1.4 | 15 | 1.3 | 0 | 14 | 6 | 3 |
| | | 16 | 1.3 | 0 | 14 | 10 | 1 |
| | | 17 | 1.7 | 1 | 13 | 3 | 9 |
| Risk Evaluation | 1.3 | 18 | 1.7 | 0 | 14 | 4 | 9 |
| | | 19 | 0.6 | 7 | 7 | 1 | 2 |
| | | 20 | 1.8 | 1 | 13 | 1 | 11 |
| Communication and Consultation | 1.3 | 21 | 0.9 | 2 | 12 | 5 | 1 |
| | | 22 | 1.5 | 1 | 13 | 7 | 5 |
| | | 23 | 1.4 | 1 | 13 | 4 | 6 |

those predefined criteria developed through proper stakeholder engagement (criterion 19). Indeed, 36% and 50% of the studies were awarded a zero in criteria 5 and 19 respectively indicating a high degree of correlation in the performance of the studies in these two criteria suggesting studies that have not identified risk evaluation criteria upfront have also failed to evaluate identified risks against those criteria (a logical conclusion).

On the other hand, most studies performed better in criterion 20 which had the highest average score of 1.8 (out of 2). This criterion investigated whether risk prioritization has been carried out through an evaluation process and whether the study had clearly identified which of the risks need further attention. This may seem counter intuitive, considering that studies performed badly in criteria 19 (evaluation of risks using predefined criteria reflecting stakeholder perspectives) but performed better in criteria 20 (prioritization of risks through evaluation). This is mainly because criterion 20 only investigated whether a study has conducted the risk prioritization process using an appropriate (often predefined) risk matrix, regardless of their choice and use of risk evaluation criteria. It was common practice for studies to adopt qualitative and generically expressed risk criteria, from a published guideline or similar. This approach allows evaluation to occur without a genuine consideration of actual criteria of relevance to the organization undertaking the risk assessment. In other words, coastal climate change risk assessment studies often end up with a list of prioritised risks that are not necessarily evaluated against criteria that reflect organizational or stakeholder objectives. As an example, a group of coastal studies in our sample developed hazard lines for different future time frames by means of biophysical modelling, integrating different sea level rise projections, which then they use to identify coastal assets that fall within those hazard lines. The risk prioritization then took place by identifying a likelihood and consequence rating for each risk. While identifying consequence ratings, studies commonly assessed consequences in the context of the well-being of a particular asset (i.e. what will happen to the physical integrity of the asset) rather than focusing on how the consequence of that particular asset failing may affect the organization's goals and objectives (e.g. maintain public safety, maintain service continuity etc.).

Overall, the 'Risk analysis: Consequences' stage of the risk assessment process has the highest average score (Table 7). This suggests that most studies have analysed possible consequences of climate change risks quite well. This reflects that, often, the focus of these studies was to develop high quality robust biophysical models and therefore most of the efforts of the study team tend to be invested in this. It also reflects that most studies have used the output of biophysical models well in order to investigate the impacts of identified hazards on assets which ultimately result in 'consequences' part of the assessment. On the other hand, the 'Risk identification' task was the worst performing among them with an average value of 0.8 out of 2. This reflects a tendency to not put the study within the broader context of the organization nor incorporating the views of stakeholders (criterion 10). This particular weakness among studies is also evident from criteria 7 (understanding organizational context of the risk assessment) and 8 (identifying local government objectives that are relevant to the risk assessment) as the average scores of these two criteria were 0.7 and 0.9 respectively. None of the studies scored full marks in criterion 7. Another striking weakness of studies was revealed by criterion 13, which investigated the robustness of a study in terms of how well it had incorporated different types of uncertainty. None of the studies were awarded full marks against this criterion, mainly due to the fact that they lacked rigor in estimating likelihood of a given event. Admittedly, most of the sample studies pre-dated the release of the IPCC's AR5. Prior to AR5, the IPCC did not publish clear guidance on how to assign probabilities to different amounts of sea level rise. Even with the release of AR5, any likelihood assessment of sea level rise is contingent upon the a priori selection of a particular RCP.

### *5.3. General findings from interviewing stakeholders of top performing studies*

We selected the top six performing studies and conducted interviews with persons from the host organisations who were involved in those particular studies and were in a position to shed some light on the utility of that study for the host organization. The questions listed in Section 4.3 prompted broad discussions with the interviewees. It was clear from discussions that, in most cases the better performing studies (according to our rankings) met the needs of the organization for which it was prepared, with some exceptions (e.g. See note on scale in Section 5.3.1). Throughout the interview process, a number of key themes arose

relevant to uptake of climate risk assessment findings through the adaptation process, which are summarised below.

#### 5.3.1. Scale

The scale at which the risk assessment is carried out appears to influence the uptake and implementation of findings. For example, one interviewee described how a climate change risk study conducted across multiple coastal councils identified risks that weren't necessarily specific (or relevant) to individual councils. While, one council within the group used the broader risk study as a tool to 'set the context' for a more detailed hazard assessment and adaptation plan, the other councils involved had yet to utilise the findings in a proactive manner. In comparison, similar risk studies carried out across a single coastal council resulted in findings that were directly tailored to their needs and resources and progressed through to the adaptation planning phase with continued engagement from staff within the organization.

#### 5.3.2. Setting the baseline risk

Another theme that arose was an appropriate treatment of existing risk (baseline risk) and communication of this during the consultation process. In particular, it seems important for stakeholders to understand their current risk and how this may change in the future. One interviewee explained how they had produced maps of future flood risk, however didn't present the 'natural' or 'current' risk. This meant that stakeholders could not place the future risk in perspective. For example, did the maps represent an increase in flood risk for their property? Did they need to adjust their insurance to deal with this? Is this an entirely new risk they haven't had to consider before? Setting an appropriate baseline of risk is an important aspect to the assessment given that in most instances it is the future change in risk that is important to the stakeholders. This will ultimately assist with developing appropriate adaptation planning.

#### 5.3.3. Communicating uncertainty

This was identified as an issue that requires improvement with respect to the risk assessment process and in particular community consultation. Stakeholders may find traditional expressions around uncertainty hard to deal with in their thinking around actions on climate change (e.g. "…A likely range of global mean sea level rise for 2081–2100 compared with 1986–2005, depending on emissions (0.40 [0.26–0.55] m for RCP2.6, 0.63 [0.45–0.82] m for RCP8.5), can be projected with medium confidence, including the contribution from ice − sheet rapid dynamics. "). Often, stakeholders expect firm numbers which cannot be provided. Without clear communication, uptake of the risk study findings may be poor. However, as discussed by Verdon-Kidd et al. (2015), the absence of this precision can provide a justification for inaction. However, this desire for certainty as a prerequisite for action is unnecessary, given that society has been able to make decisions and plan for the future in the context of uncertainty in fields as diverse as defence, finance and insurance. It is simply a matter of changing the way uncertainty is communicated.

#### 5.3.4. Public engagement

Dealing with climate risk assessment is considered a complex problem, as is the question of when to engage stakeholders in this process. As one interviewee said "when do we open the can of worms?" If this occurs too early in the process, it can make it difficult to set boundaries on the study (as each stakeholder will have a different idea of what is important to them). However, if it occurs too late in the process, stakeholders will feel disempowered. One interviewee noted the lack of community interest (community disengagement) in their climate change risk assessment and adaptation planning activities and attributed this partially to attempting to engage too late in the process (at the adaptation stage). The interviewee also noted that the lack of historical or current management issues (e.g. a big storm event that caused flooding/erosion) in the region had created an additional roadblock. That is, "people don't think it will happen unless they have seen it in their lifetime". This issue was reiterated by a second interviewee who noted that residents were reluctant to accept future risk maps without having directly experienced a similar event (e.g. costal erosion, flood event) first hand.

The most appropriate course of action may be to first identify the boundaries of the study (what regions are we looking at and why, what assets, what timeframe) and then invite stakeholder consultation to identify possible consequences (and therefore the risks). Importantly, engaging stakeholders at this stage of the project will assist in building trust in the project outcomes and ultimately increase the acceptance and uptake of the recommendations. It is important that council first identifies what they are responsible for internally to identify their corporate risks (set the boundary) before "the can of worms is opened".

#### 5.3.5. Integration of coastal risks into council's risk-register

Risk identification needs to be undertaken by a local council on a periodic basis. Most council maintain a list or register of risks, and schedule regular reviews of that register. These reviews take such things into account as changes in the council's services and operating environment and identify all risks that impact on the council's activities, regardless of whether the risks are under the council's control. This register of risks therefore represents a useful tool in which climate change/coastal risk can be integrated within a council's overall risk related activities. To date, most climate/coastal risk studies have been carried out opportunistically (when funding is available) and separately from the council's overarching risk management process. Integrating climate/coastal risk assessment in the risk register would therefore most likely improve the effectiveness and uptake of such studies.

Of the organisations interviewed, only one had integrated the findings of the climate change risk assessment into their risk register. This has resulted in the risks associated with climate change being integrated in the cross section of daily council operations (from infrastructure planning right through to fleet efficiency, procurement and purchasing services). That is, climate change related risks are "embedded in business as usual" which has resulted in a "changing organizational mindset". This approach therefore appears quite successful as it means the entire organization is engaged rather than just an isolated group of people directly involved with coastal management, for example.

## 6. Discussion

Our findings indicate a degree of misuse of coastal climate change risk assessments by local government, compounded by confused terminology and a lack of alignment between climate risk assessments and both corporate needs and responses. In this section we discuss some of the key observations that we encountered starting with our sample selection, through our evaluation of study samples to interviewing of stakeholders from the host organisations.

### 6.1. Mainstreaming climate change risks within the councils

One key issue that was evident in our analysis results was the poor performance of studies in both extracting risk evaluation criteria (that reflects organization's corporate objectives) through effective stakeholder engagement as well as appropriate use of those criteria in the risk evaluation process. Jones and Preston (2011) argued that capacity of an organization to carry out successful risk assessment will differ from the capacity to implement actions to manage those risks. The assessment of climate change risks is often highly technical, but their management is governed by institutional and organizational factors. As resources required to manage future climate risks often compete with present day challenges of coastal councils in terms of maintenance and development of infrastructure, without proper alignment with existing objectives and risk management activities of a Council, it is unlikely

that the Council will allocate resources for the management of climate change risks. Therefore, 'mainstreaming' of policies and measures that address climate change into development planning and ongoing organizational decision-making within the council can ensure the long-term sustainability of investments as well as to reduce the sensitivity of development activities to both today's and tomorrow's climate (Klein et al., 2007, Sharma and Tomar, 2010). This was confirmed by our interview process which identified that only one organization from our top performing sample integrated identified risks in their organizational risk register. This has resulted in the risks associated with climate change being integrated in the cross section of daily council operations (from infrastructure planning right through to fleet efficiency, procurement and purchasing services). In this regard, our study finding of lack of alignment of the climate change risk assessment process with the overarching organizational objectives is crucial and our finding highlights a major deficiency of coastal practice that could impede effective adaptation within coastal councils.

### 6.2. Context settings and risk reporting

The 'Establishing the context' stage of risk assessment is found to be the 2nd worst performing stage with an average score of 1.1 (out of 2). Out of the 8 criteria within this stage, none of the studies scored full marks in criterion 7 which aimed to evaluate whether there were any attempts to outline the internal risk management context of the host organization. As an example, we examined whether the introductory part of the study reported previous activities within the organization that led to that particular study being undertaken and how the output of that study was likely to be used in future policy making or planning activities. Jones and Preston (2011) suggested that risk assessment approaches which confine themselves to a narrow viewpoint of climate change risks can become restricted in a way that reduces the chance of findings to be integrated into mainstream decision making. Although most studies performed poorly in the context setting criterion of our analysis (criterion 7), our interviews with the stakeholders with better performing studies suggested that better scoping (in terms of scale, engagement strategy, understanding baseline risks etc. as discussed in Section 5.3) and context setting helped them convey the risk assessment results to the decision makers when pursuing the next steps. One potential solution of this lack of context setting can be designing a systematic scoping exercise which allows the host council stakeholders to understand the broader contexts of coastal climate change risks, including the broader organizational risk management context, and then commissioning a formal risk assessment study where further attention to risk is warranted. (see three-tier climate change risk assessment process developed by CoastAdapt tool at www.coastadapt.com.au and presented in Tonmoy et al., 2018) This approach can optimise the use of limited adaptation resources.

### 6.3. The influence of state government on local government risk assessment

In Australia, risk assessment by local councils is commonly conducted within frameworks established by state government. That is, risk assessment is guided by legislation and manuals established at the state level. Therefore, to obtain funding for risk studies (from the state), the spatial boundaries tend to be restricted to assets or hazards (e.g. estuaries, beaches etc.) identified by, and of interest to the state government. However, this may not match the objectives at the local level. For example, a particular beach or foreshore may not have issues of state significance, but may be of particular importance for a local council.

State guidelines for coastal development overlap with flood management planning regulations and some funding derives from those sources. Much of the flood management planning has been developed to deal with floodplains and estuaries of larger inland rivers, as opposed to coastal estuaries and urban flooding (both of which are critical issues for coastal councils). Accessing external funds to carry out risk assessment and adaptation studies for such sites can therefore be problematic.

This issue appears to be state specific, however, with one interviewee commenting that they use a bottom up approach, where the local council first determines the hazard(s) they wish to assess, which is then followed up by an application for funding to the state government. However, funding from state government level, while most common, is not the only way funds may be acquired. One interviewee noted that their funding rarely came from the state government and most climate change related funding was obtained through the National Disaster Resilience Program (NDRP). This highlights an issue with attempting to develop a national framework for risk assessment, when councils obtain funding from different sources with different interests and having varying degrees of control over the process.

## 7. Conclusions

In this study, we investigated the adherence of unpublished 'grey literature' of coastal climate change studies in Australia to ISO31000 standard risk management principles. This helped us understand the state of practice among coastal practitioners in Australia and to develop insights on critical success factors for conducting an effective coastal climate change risk assessment. We explored those aspects that can ultimately assist in progressing adaptation activities within the host council. Our key findings include the following.

- There is a significant inconsistency among terminologies in the coastal climate change risk assessment unpublished literature as studies use "risk", vulnerability and "hazard" concepts interchangeably despite their separate objectives and aims. This inconsistency also prevails among the peak-body state level guidelines.
- Utility of a risk assessment study in progressing adaptation planning within the council largely depends on how successfully the study is scoped, the effectiveness of communication and how well identified risks are evaluated against criteria that closely match the organization's corporate objectives. In other words, consistent reporting of climate change risks with other organizational business risks increases the chance of uptake by the decision makers and increases the possibility of getting necessary funding to progress adaptation activities.
- Coastal councils should be proactive and have a clear understanding of their objectives and their role and overall responsibilities for climate change risk management. This includes assuming a primary role to clearly understand the context, including the geographical extent, time frames, legal environment, hazards to be considered and the expected level of assessment of deliverables. Many aspects of the coastal risk management context are more sensibly established at state government level in Australia.
- Broad, continuing consultation is very important and deserves significant attention. However, it is recognised that there is a need for some information prior to entering the necessary conversations with stakeholders. The context needs to be established and would likely involve some up-front, preliminary study of the possible extent of hazards and the assets that would be affected.
- Best practice risk assessment makes genuine attempts to address uncertainty. This will require significant effort and goes beyond many of the qualitative approaches that have been made in the past. As much as possible, a probabilistic approach to assessing the likelihood of risks is strongly recommended. The adoption of benchmarks and scenarios with no assessed likelihood does not result in best practice risk assessment.
- Care is needed in applying available guideline documents to ensure that they are consistent with standard risk assessment practice and relevant for coastal climate change. The *CoastAdapt* tool aims to provide access to data and advice alongside relevant state government level guidance. One particular issue with different guideline

documents is the adoption of nomenclature which differs from that applied in standard practice.

- The key influencing factor of coastal climate change risk is sea level rise although changes to storminess are also important. Sea level rise will combine with changes to storminess to exacerbate coastal erosion, inundation and flooding with consequences to various assets such as infrastructure, settlements, beaches and ecological communities.

While our study focuses on coastal climate change risk assessment within Australia, anthropogenic sea level rise is a global issue, potentially impacting 72% of the most populated nations of the world. The insights presented in this paper are of direct relevance to any coastal community facing the climate change adaptation challenge since good adaptation is underpinned by successful risk assessment. Further, the broad ideas expressed within the paper are applicable to other climate change risks which, while important to some coastal councils, are not specifically coastal in nature. Examples include risks related to changes in bushfire intensity and frequency, caused by an overall drying climatic trend.

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